Loop CTRL → A120 → AKF
Type: CLC12
Version 1.1
Diskettes $3^1/_2$" and $5^1/_4$"

Configuration Guide
DOK-276557.20-0291

Belongs to software kit E-No. 424-271575

Notes
Table of Contents

Part I How to Proceed?

Part II Closed Loop Control Function Blocks

Part III Application

Part IV Appendix

Part V

Part VI

Part VII

Part VIII

Part IX

Notes
Table of Contents

Notes

Application Note

Caution The relevant regulations must be observed for control applications involving safety requirements.
For reasons of safety and to ensure compliance with documented system data, repairs to components should be performed only by the manufacturer.

Training
AEG offers suitable training that provides further information concerning the system (see addresses).

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Addresses
The addresses of our Regional Sales Offices, Training Centers, Service and Engineering Sales Offices in Europe are given at the end of this publication.

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Terminology

Note This symbol emphasizes very important facts.

Caution This symbol refers to frequently appearing error sources.

Warning This symbol points to sources of danger that may cause financial and health damages or may have other aggravating consequences.

Expert This symbol is used when a more detailed information is given, which is intended exclusively for experts (special training required). Skipping this information does not interfere with understanding the publication and does not restrict standard application of the product.

Path This symbol identifies the use of paths in software menus.

Figures are given in the spelling corresponding to international practice and approved by SI (Système International d' Unités).
I.e. a space between the thousands and the usage of a decimal point
(e.g.: 12 345.67).

AKF	abbr. instruction list (IL), ladder diagram (LD), unction block diagram (FBD)	
IL	instruction list	
FPF	fire protection flap	
DT1-part	real differential part of controller	
FB	function block	
HVAC	heating, ventilation and air conditioning	
NW	network	
P-controller	proportional-action controller	
PI-controller	proportional-plus-integral controller	
PID-controller	proportional-plus-integral-plus-derivative controller	
PADT	programming and debugging tool	
CLC-FB	closed loop control function block	
PC	programmable controller	
I&C	central instrumentation and control	
<Cr>, <Return>	use carriage-return key	
<Ctrl>	use control-key	all three keys
<Alt>	use alternate-key	held down:
<Del>	use delete-key	warm restart

Objectives

Present software and documentation can only be used together with software-package Dolog AKF → A120.
This manual is designed for configuration of closed-loop control programs on Modicon A120.

It contents information about installing the software on personal computer and the use of function blocks. The configuring of FBs (parameters, time etc.) will be described. As an introduction into the configuration of closed-loop control programs using CLC 12C software, the software kit contains an application example of heating, ventilation and air conditioning and the application of controlling an reacting-tank in process engineering.

Arrangement of This Guide

General This part contains the preface of the documents, describes the handling of install-disks and contains a detailed table of contents of this manual.

Part I Checklist for proceeding with present software kit.

Part II Requirements, installation and specification of closed-loop control function blocks.

Part III Installation and specification of application 'I&C, HVAC'.

Part IV	Appendix	
	Addresses	Contain the addresses of the sales agencies at home and abroad.
	Publicatons Comment Form	Please use this form a lot, if you have any questions or corrections regarding the doumentation or software.

Related Documents

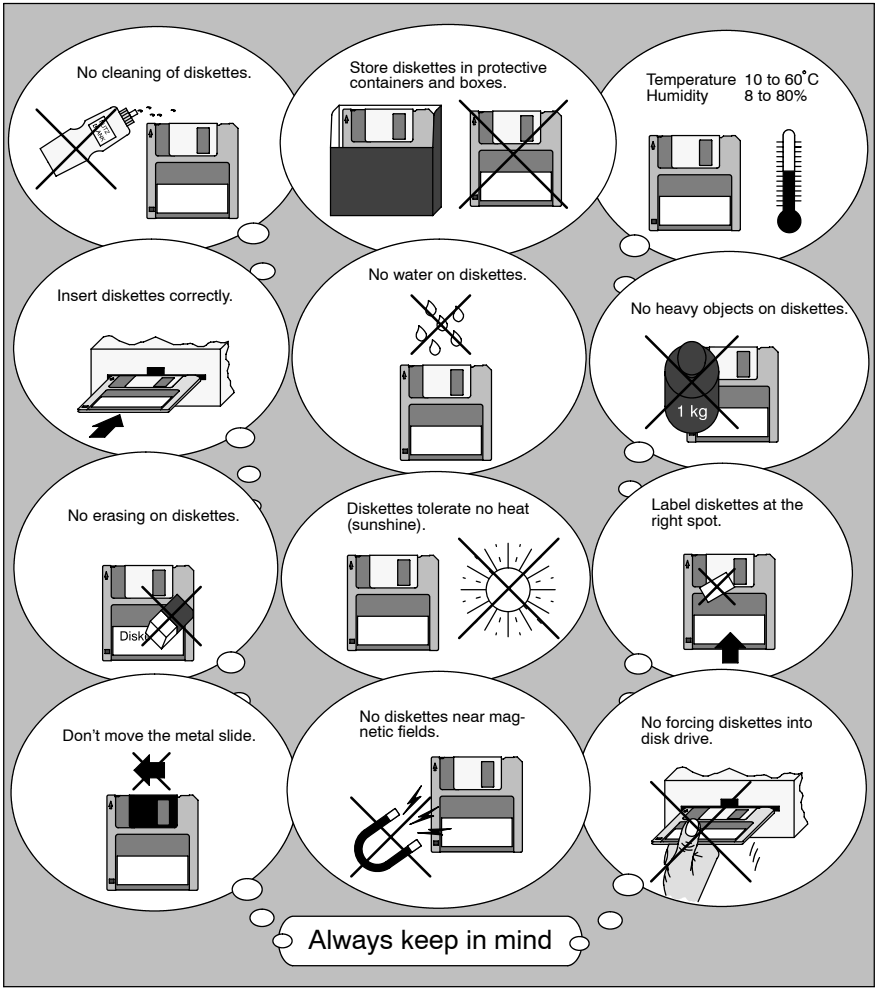
Software Kit
Dolog AKF → A120
Type: AKF12
E No 424-271521

Validity Note

This manual is assigned for software CLC12 version 1.1.

Translation of description DOK-275578.20.

Handling 3 $^{1}/_{2}$" Diskettes


No cleaning of diskettes.
Store diskettes in protective containers and boxes.
Temperature 10 to 60°C
Humidity 8 to 80%
Insert diskettes correctly.
No water on diskettes.
No heavy objects on diskettes.
1 kg
No erasing on diskettes.
Diskettes tolerate no heat (sunshine).
Label diskettes at the right spot.
Don't move the metal slide.
No diskettes near magnetic fields.
No forcing diskettes into disk drive.
Always keep in mind

Handling 5 1/4" Diskettes

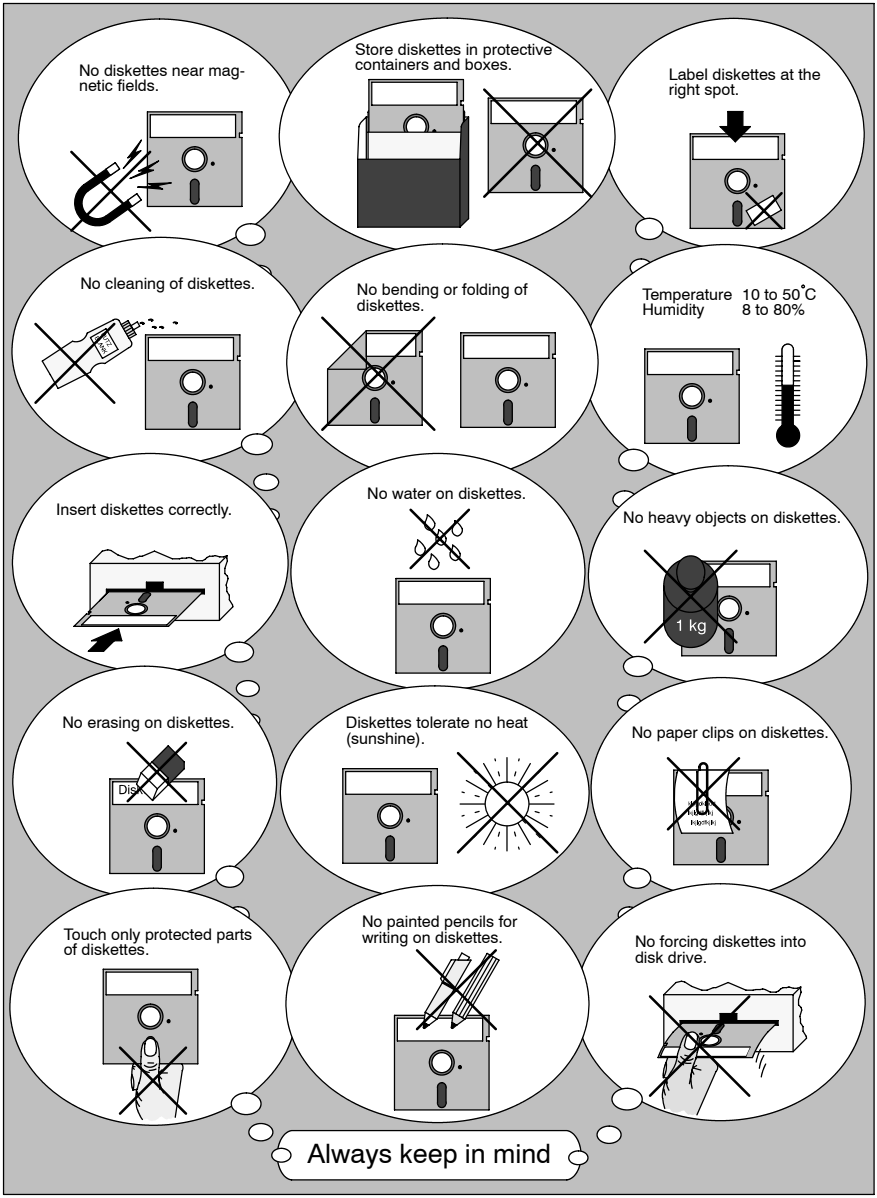

No diskettes near magnetic fields.
Store diskettes in protective containers and boxes.
Label diskettes at the right spot.
No cleaning of diskettes.
No bending or folding of diskettes.
Temperature 10 to 50°C
Humidity 8 to 80%
Insert diskettes correctly.
No water on diskettes.
No heavy objects on diskettes.
1 kg
No erasing on diskettes.
Disk
Diskettes tolerate no heat (sunshine).
No paper clips on diskettes.
Touch only protected parts of diskettes.
No painted pencils for writing on diskettes.
No forcing diskettes into disk drive.
Always keep in mind

Table of Contents

Part I How to Proceed? 1

Chapter 1 Checklist 3

Part II Closed Loop Control Function Blocks 5

Chapter 1 Requirements 7

Chapter 2 Installation of Function Blocks 9

Chapter 3 General Information about FBs 11
3.1 Structure of FBs 12
3.2 General Information about CLC-FBs 13
FB305 PID1.16 PID controller with 16 bit fixed point arithmetics 15
FB306 PID1.32 PID controller with 32 bit fixed point arithmetics 21
FB310 ZR1 Two-position controller for A120 27
FB311 PDSR1 PD-step-action controller ..... for A120 31
FB315 DR1 Three-position controller for A120 37
FB320 PBM1 Pulse-duration Modulator for A120 41

Part III Application 47

Chapter 1 Installation Application 49
1.1 Installation of applications 50
1.1.1 Installation of application HVAC 50
1.1.2 Installation of application REACT 51

Chapter 2 Applications 53
2.1 Open Loop and Temperature Control of a Ventilation System in HVAC Techniques 56
2.1.1 Open Loop Control 59
2.1.2 Mixed air temperature control 62
2.1.3 Room Temperature Control 63
2.2 Closed Loop Control of a Reacting Tank in Process Engineering 66
2.2.1 Sequence Control and Closed Loop Control 66

Part IV Appendix 69

Addresses 71

Publications Comment Form 81

Part I
How to Proceed?

Chapter 1
Checklist

The following list describes how to use this closed-loop control manual and how to handle the loop control software in the best way.

Before using loop control function blocks take a look at the following checklist and note the software details in the corresponding chapters.

- ❒ Get familiar with the conditions for using loop control software (part II, chapter 1).
- ❒ Have you fullfilled the conditions of the first point?
- ❒ Install the loop control function blocks (part II, chapter 2).
- ❒ To check software operation, install one of the applications (part III, chapter1).
- ❒ Start AKF program using the 'AKF12'-command on your PADT (see also software kit 'AKF12').
- ❒ With SeTup menu type the name of 'PLant' and 'PC Station' that you want to choose for applications (see also software kit 'AKF12').
- ❒ Print closed-loop control program using print menu 'program list' (see also software kit 'AKF12').
- ❒ Get familiar to functionality of application using the program list and the manual's descriptions (see also software kit 'AKF12').
- ❒ Edit your open loop program using 'AKF12' (see also software kit 'AKF12').
- ❒ Copy the neecessary loop control Function Blocks to your actual plant using the 'Special' and 'Copy Files' commands (see also software kit 'AKF12').
- ❒ Create your closed loop program under using the function blocks (see also part II).

The specific closed-loop control parts are now complete. Finally you can prepare the AKF program for loading it to the connect PC or return to other work on the given plant (AKF12, part 'programming', chap. 'Programming Sequence').

Part II
Closed Loop Control Function Blocks

Chapter 1
Requirements

This chapter enables you to perform closed loop control using AKF software package Dolog AKF → A120 and the loop control software CLC 12.

To guarantee proper operation of software ensure the following conditions:

- IBM compatible programming and debugging tool (personal computer) with fixed disk drive and external-disk drive (3 1/2" or 5 1/4") and with installed software Dolog AKF → A120

- software conditions:

Kind of software	**type**	**number**
A120:		
ALU 200 basic software	BSW 124	275121.00
ALU 201 basic software	BSW 123	275120.00
ALU 202 basic software	BSW 123	275120.00
PADT:		
Dolog AKF → A120 programming software	AKF12	E-Nr. 424-247197 version 2.0 or higher
Loop CTRL → A120 → AKF Closed loop control FBs	CLC12	E-Nr. 424-271575 version 1.0

- Knowledge about project planning of the A120 using the software kit Dolog AKF → A120

Chapter 2
Installation of Function Blocks

This chapter describes you how to copy closed loop control function blocks.

The loop control function blocks (CLC-FBs) are equipped with AEG defined numbers. Nevertheless these numbers can be freely changed by the customer when copying function blocks from diskette to PC Station. To keep always best survey and to make survive activities less difficult, we recommend to use the same numbers or to commit function block numbers in your company.
Use the following procedure to copy FBs:

Step 1 Start AKF12 program

Step 2 Insert CLC12-diskette in your disk drive (e.g. A:\)

Step 3 You are in the Plant, entered during installation of AKF12 (e.g. ”C:\AKF12”)

Step 4 Select ”SeTup”, ”PC Station”, ”PC Station Name” in AKF12 menu (e.g. ”CLC”)

Step 5 Select menu ”Special”, ”Copy Files”

Step 6 To specify source files type: A:\CLC12*.* (note A:\ is the name of disk drive in which youve inserted the CLC12 diskette, eventually this drive can be B:\ )

Step 7 When entering the return key in the ”Target” line (empty line), the files on the inserted diskette will be copied into the PC station determined with SeTup (CLC12)

Menu entries for step 6 and step 7:
(parameter: /V)

```
Start Copying Files
SOurce: A:\CLC12\*.*
Target:
Parameter: /V
```

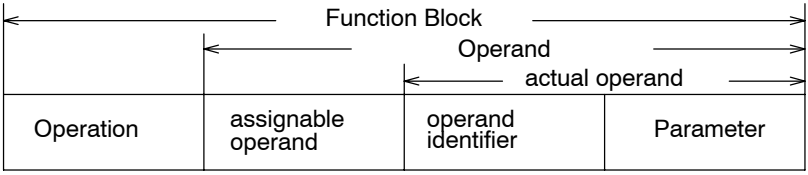
From this PC station the required FBs can be copied to the actual PC station containing the user program (the recommendation mentioned above is automatically kept when proceeding in this way).
For this Step 4 to Step 7 have to be repeated.
To Step 4: Type the name of PC station you want to work with.
To Step 6: ”Source” is the directory of PC station ”CLC”. Instead of *.* insert the number of required FB.
To Step 7: The selected PC station remains the target directory.

Chapter 3
General Information about FBs

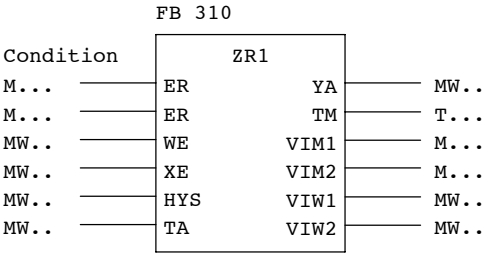
3.1 Structure of FBs

Every function block consists of one operation and the necessary operands for executing the operation.

The operation determinates **which function** will be executed by the function block. The operand determinates **which variable** will be used when executing the operation.



e.g. ZR1 e.g. ER,X e.g. MW, M e.g. 2.3, 4.5



☞ **Note** Only one FB is allowed in each network

Conditional- / unconditional FB call
The operation of every function block can be enabled with a 'Conditional call' (edit menu). Doing this causes AKF program to perform an additional FB marker input. Setting the conditional input enables FB operation, resetting the input turns the FB operation off. The output operands then will not be changed until the FB is reactivated. This allows for instances where output operands are shared with

further FBs in cases of process dependant operating modes (e.g. split-range control) - or simply to stop FB operation. The conditional input is next to the name of function block (here ZR1).

Conditional input e.g. E2.1 → conditional call
no conditional input → unconditional call

The operand identifier determinates if it is e.g. an output variable (Q), Input variable (I), a marker byte (MB) etc. This information is demanded by Dolog AKF from the system. It is not possible to write a marker bit to places which are assigned for marker words. Wrong inputs will not be accepted (syntax check).

Valid characters of variables in Function Block Diagrams:

Condition	conditional or unconditional call (enable) of function block
M...	for input/output value or marker with bit format
MB..	for input/output value or marker with byte format
MW..	for input/output value or marker with word format
MD..	for input/output value or marker with double word format

The points signify the required parameters

3.2 General Information about CLC-FBs

The Closed Loop Function Blocks of MODICON A120 can be copied into an existing PC station and used like regular FBs.

Inserting a Function Block into a Network causes the AKF program to prepare the finally program linkage with assignment of fundamental part of Function Block code and additional the code for calling the FB in OB (see also FB descriptions). With every further insertion of the same Function Block only the call of the new FB is added to the code to be linked. The required program memory can be kept to a minimum in this way.

The Loop Control Function Blocks run without additional timing system using only timer controlled sampling. Therefore every CLC-FB gets one or more timer functions assigned at TMx variable. The sampling time, unless otherwise specified (see FB descriptions), should be determinated adapt to the conditions of

process loop. Usual values are 1/5 - 1/10 of loop control relevant system time constants.

The required memory allocation for internal variables, controller input- and output variables and controller parameters are completely assigned at the Controller Function Block. There is no exceptional handling of data in the Data Block (DB) or consideration of restricted data areas.

The number of timer addresses used can be minimized by assigning the same timers to several function blocks in cases when the sampling time is determined as zero. (e.g. ZR1-, DR1 continuous operation or PID controller in P controller mode). Also the double words that have to be assigned to some controllers can be used commonly. They are only used for buffer storage.

In displaying A120 signals using ”Online List” it should be considered that variables identified as controllable (CE) will be overwritten for one program cycle with given list value after activating the transmit using the transmit command in the AKF menu. The controller outputs have storing characteristics and therefore should only be listed as viewable (no identifier). Identifying controller output variables as force variables should be avoided if regular and continual controller operation is to be guaranteed. (The fixing of output variables causes uncontrollable influence in FB operation)

FB305 PID1.16 PID controller with 16 bit fixed point arithmetic

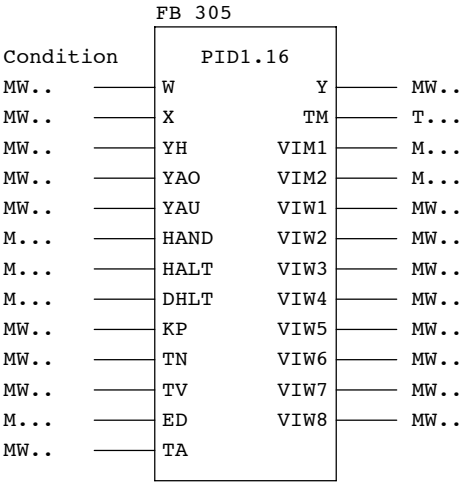
1 Function

The closed loop control function block PID 1.16 is a freely parametrizable PID controller with 16 bit fixed point arithmetics. PID 1.16 has the following characteristics

- negative KP values possible (change of control direction)
- D-, and I-part can separately and bumpless turned on/turned off
- D-part with bumpless change over to system deviation or actual value
- D-part part combined with 1st order lag element for controlled step response (DT1)
- Operation with anti windup reset (AWR)
- Manual input with setpoint correction of integral part for bumpless return to automatic mode
- Operating mode HALT for keeping the last value of controller output with setpoint correction of integral part
- Dynamic HALT with positive edge trigger at DHLT-input during next FB cycle
- Limiting of controller output to minimum/maximum value
- Complete protection against arithmetic overflows; thus higher reliability
- FB operating time less than 10 ms

2 Display

2.1 Funktion Block Symbol



2.2 FB structure

Assignable parameter		Meaning
PID1.16		Operation (Call)
W	MW - addr.	setpoint value
X	MW - addr.	actual value
YH	MW - addr.	manual input
YAO	MW - addr.	maximum output value
YAU	MW - addr.	minimum output value
HAND	M - addr.	operating mode HAND (priority over HALT)
HALT	M - addr.	operating mode HALT
DHLT	M - addr.	dynamic HALT for next FB cycle
KP	MW - addr.	controller gain
TN	MW - addr.	integral-action time (in 0.1 s); TN $\leq$ 0: I-part is turned off
TV	MW - addr.	derivative-action time (in 0.1 s); TV $\leq$ 0: D-part is turned off
ED	M - addr.	change over D-part (0 for KP $*$ Xd, 1 for KP $*$ -X)
TA	MW - addr.	sampling time (in 0.1 s)
Y	MW - addr.	manipulated variable (controller output)
TM	T - addr.	timer
VIM1	M - addr.	internal organization data (bit)
VIM2	M - addr.	internal organization data (bit)
VIW1	MW - addr.	internal organization data (word)
VIW2	MW - addr.	internal organization data (word)
VIW3	MW - addr.	internal organization data (word)
VIW4	MW - addr.	internal organization data (word)
VIW5	MW - addr.	internal organization data (word)
VIW6	MW - addr.	internal organization data (word)
VIW7	MW - addr.	internal organization data (word)
VIW8	MW - addr.	internal organization data (word)

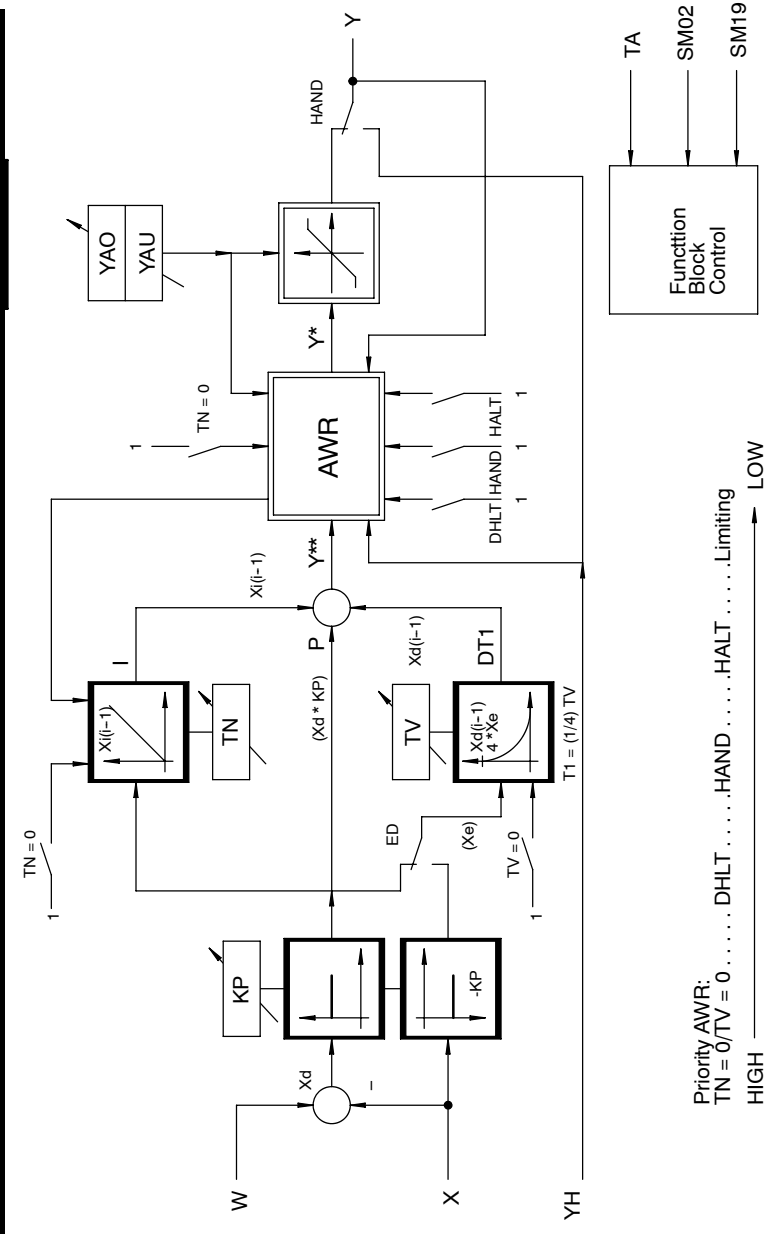


Figure 1 Controller design

3 Configuration

The function block can be copied from the source file (PADT or Diskette) to the target file of the selected PC station (ref. chapter LEERER MERKER).

3.1 Parametrization

The parametrization of PID 1.16 controller has no restrictions - Arithmetic overflows will be kept MAXINT limits the way that direction (sign) of substituted variable is the same as the direction of the unrepresentable, overshoot one (no undefined 'saw-teeth' effects). Controller operation without limited output value can be reached with regards to the overall arrangement of control loop.

Note :

Step changes in setpoint value will be amplified with a gain of 5 * KP at the instant of step change and are given out additional to the actual controller output value (once amplified by controller gain and four times by DT1-part, because of internal determination TV/T1 = 4).

The following course of the controller output value is essentially determined by the additional conditions of the control loop, mostly by system time constants. The limiting of controller output in this connection, is in the main dependant on the course of the integral part, whose settling to an fixed value can only be done over the system loop.

Step changes in setpoint value can be (preferably in PI mode) transformed into a slower settling of the control loop, with bumpless change in controller output value, when simultaneous causing a positive edge trigger at DHLT input. In that case DHLT forces the controller to take over the normally occuring step change in the controller output into the integral part (one cycle). The former controller output value temporary remains as the output value. The following course of controller output value is essentially determinated by the changing of the integral part.

Table 1 Determination of sampling time

Controller	min	typ	max
P	0	-	-
PI	-	≤ 0.2*TN	-
PD	-	≤ 0.05*TV	-
PID	-	≤ 0.05*TV	-

3.2 FB operating times

☞ **Note** The given operating times are valid when using ALU 202.

Operating times during sampling cycle:

	mode			
Controller	**normal**	**AWR****	**HAND**	**HALT**
P	3.08 ms	3.20 ms	2.98 ms	3.01 ms
PI	5.06 ms	4.25 ms	4.02 ms	4.03 ms
PD	3.79 ms	3.62 ms	2.99 ms	3.02 ms
PID	5.41 ms	4.46 ms	4.03 ms	4.94 ms

Operating times in other cycles:
always 2.32 ms

3.3 Program memory

first FB-call in OB: 5 010 Byte*
every further call: + 159 Byte

** if I part works

* The given value represents worst case value and is valid when the Function Block is the only one called in the OB. If however commands used in your closed loop control functions already exist in your program, only the additional program parts will cause an increase in the total linked program length (hence saving in program memory).

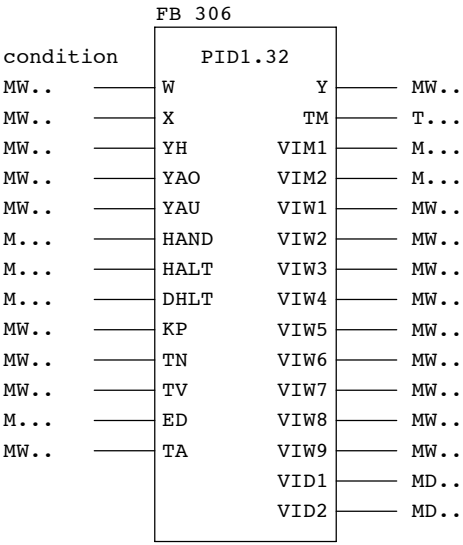
FB306 PID1.32 PID controller with 32 bit fixed point arithmetics

1 Function

The Closed Loop Control Function Block PID 1.16 is a freely parameterizable PID controller with 16 bit fixed point arithmetics for input and output. The calculation of I- and DT1-part and the summing of the internal values for building the controller output signal are done with 32 bit accuracy.

- negative KP values possible (change of control direction)
- D-, and I-part can separately and bumplessly turned on/off
- D-part with bumpless change over to system deviation or actual value
- D-part part combined with 1st order lag element for controlled step response (DT1)
- Operation with anti windup reset (AWR)
- Manual input with setpoint correction of integral part for bumpless return to automatic mode
- Operating mode HALT for keeping the last value of controller output with setpoint correction of integral part
- Dynamic HALT with positive edge trigger at DHLT-input during next FB cycle
- Limiting of controller output to minimum/maximum value
- Complete protection against arithmetic overflows; thus higher reliability
- FB operating time less than 10 ms

2 Display


FB 306
PID1.32
condition
MW..
MW..
MW..
MW..
MW..
M...
M...
M...
MW..
MW..
MW..
M...
MW..
W
X
YH
YAO
YAU
HAND
HALT
DHLT
KP
TN
TV
ED
TA
Y
TM
VIM1
VIM2
VIW1
VIW2
VIW3
VIW4
VIW5
VIW6
VIW7
VIW8
VIW9
VID1
VID2
MW..
T...
M...
M...
MW..
MW..
MW..
MW..
MW..
MW..
MW..
MW..
MW..
MD..
MD..

2.1 FB structure

Assignable parameter		Meaning
PID1.32		Operation (Call)
W	MW - addr.	setpoint value
X	MW - addr.	actual value
YH	MW - addr.	manual input
YAO	MW - addr.	maximum output value
YAU	MW - addr.	minimum output value
HAND	M - addr.	operating mode HAND (priority over HALT)
HALT	M - addr.	operating mode HALT
DHLT	M - addr.	dynamic HALT for next FB cycle
KP	MW - addr.	controller gain
TN	MW - addr.	integral-action time (in 0.1 s); TN $\leq$ 0: I-part is turned off
TV	MW - addr.	derivative-action time (in 0.1 s); TV $\leq$ 0: D-part is turned off
ED	M - addr.	change over D-part (0 for KP $*$ Xd, 1 for KP $*$ -X)
TA	MW - addr.	sampling time (in 0.1 s)
Y	MW - addr.	manipulated variable (controller output)
TM	T - addr.	timer
VIM1	M - addr.	internal organization data (bit)
VIM2	M - addr.	internal organization data (bit)
VIW1	MW - addr.	internal organization data (word)
VIW2	MW - addr.	internal organization data (word)
VIW3	MW - addr.	internal organization data (word)
VIW4	MW - addr.	internal organization data (word)
VIW5	MW - addr.	internal organization data (word)
VIW6	MW - addr.	internal organization data (word)
VIW7	MW - addr.	internal organization data (word)
VIW8	MW - addr.	internal organization data (word)
VIW9	MW - addr.	internal organization data (word)
VID1	MD - addr.	internal organization data (double word)
VID2	MD - addr.	internal organization data (double word)

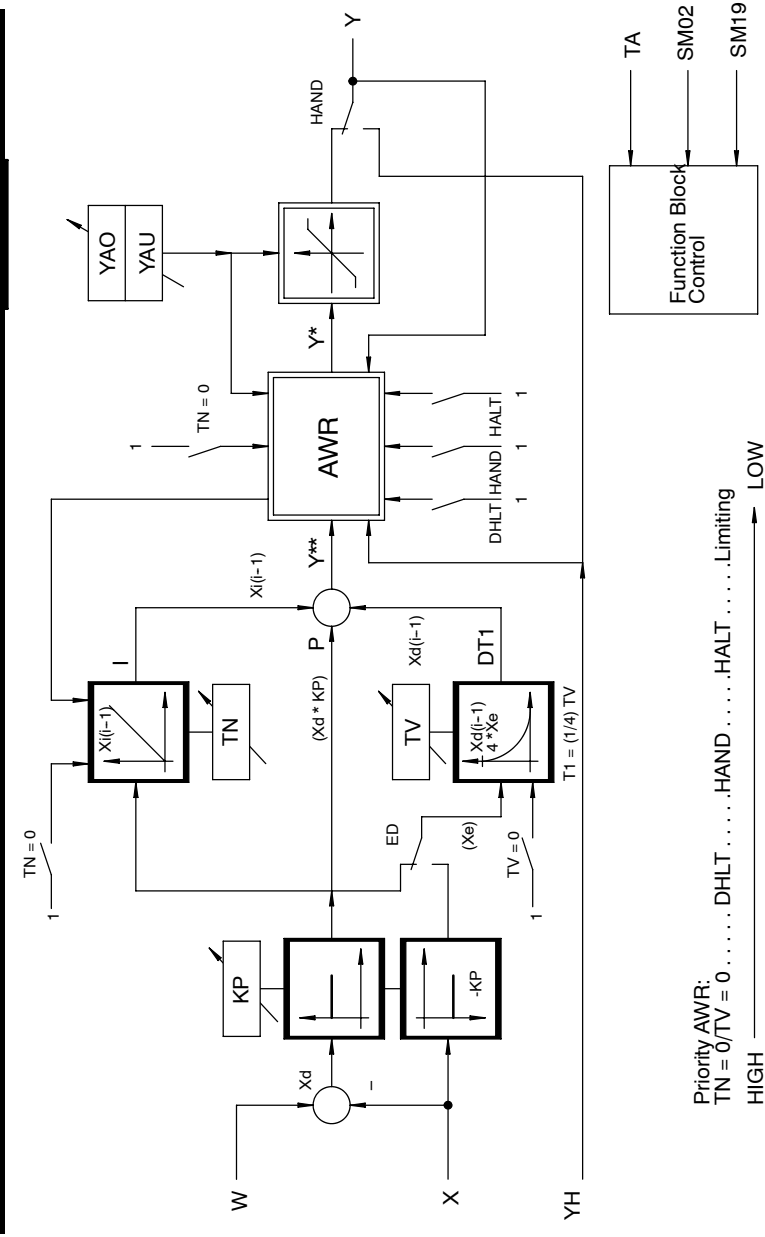


Figure 2 Controller design

3 Configuration

The function block can be copied from source file (PADT or Diskette) to the target file of the selected PC station (ref. chapter LEERER MERKER).

3.1 Parameterization

The parametrization of PID 1.16 controller has no restrictions - Arithmetic overflows will be kept within MAXINT limits the way that direction (sign) of substituted variable is the same as the direction of the unrepresentable, overshooten one (no undefined 'saw-teeth' effects). Controller operation without limited output value can be reached with regards to the overall arrangement of control loop.

Note :

Step changes in setpoint value will be amplified with a gain of 5 * KP at the instant of step change and are given out additional to the actual controller output value (once amplified by controller gain and four times by DT1-part, because of internal determination TV/T1 = 4).

The following course of the controller output value is essentially determined by the additional conditions of the control loop, mostly by system time constants. The limiting of controller output in this connection, is in the main dependant on the course of the integral part whose settling to an fixed value can only be done over the system loop.

Step changes in setpoint value can be (preferably in PI mode) transformed into a slower settling of the control loop, with bumpless change in controller output value, when simultaneousley causing a positive edge trigger at DHLT input. In that case DHLT forces the controller to take over the normally occuring step change in the controller output into the integral part (one cycle). The former controller output value temporary remains as the output value. The following course of controller output value is essentially determinated by the changing of the integral part.

Table 2 Determination of sampling time

Controller	min	typ	max
P	0	-	-
PI	-	≤ 0.2*TN	-
PD	-	≤ 0.05*TV	-
PID	-	≤ 0.05*TV	-

3.2 FB operating times

☞ **Note** The given operating times are valid when using ALU 202.

Operating times during sampling cycle:

	mode			
Controller	**normal**	**AWR**	**HAND**	**HALT**
P	3.43 ms	3.64 ms	3.27 ms	3.27 ms
PI	8.74 ms	6.42 ms	6.29 ms	8.7 ms
PD	3.79 ms	4.0 ms	3.27 ms	3.27 ms
PID	9.1 ms	6.78 ms	6.29 ms	8.73 ms

Operating times in other cycles:

always 2.56 ms

3.3 Program memory

first FB-call in OB:	6 150	Byte*
every further call:	+ 177	Byte

* The given value represents worst case value and is valid when the function block is the only one called in OB. If however commands used in your closed loop control functions already exist in your program, only the additional program parts will cause an increase in the total linked program length (hence saving in program memory).

FB310 ZR1 Two-position controller for A120

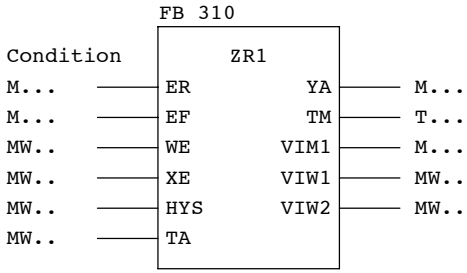
1 Function

The Function Block ZR1 transforms an internally formed system deviation into a binary state for the output marker YA. If the absolute value of the system deviation (WE-XE) overranges by a half of the hysteresys value (HYS) the output will be set dependant (sign) on the deviation value.

- Assigning hysteresis and sampling time
- Continuous operation setting TA = 0

2 Display

2.1 Function block symbol



2.2 FB structure

Assignable parameter		Meaning
ZR1		Operation (Call)
ER	B - addr.	function block reset; ER = 1: reset of YA
EF	B - addr.	enable: EF = 0: freezes YA
WE	MW - addr.	setpoint value
XE	MW - addr.	actual value
HYS	MW - addr.	hysteresis
TA	MW - addr.	sampling time (in 0.1 s); TA = 0 for continuous operation
YA	M - addr.	manipulated variable (controller output signal)
TM	T - addr.	timer
VIM1	M - addr.	internal organization data (bit)
VIW1	MW - addr.	internal organization data (word)
VIW2	MW - addr.	internal organization data (word)

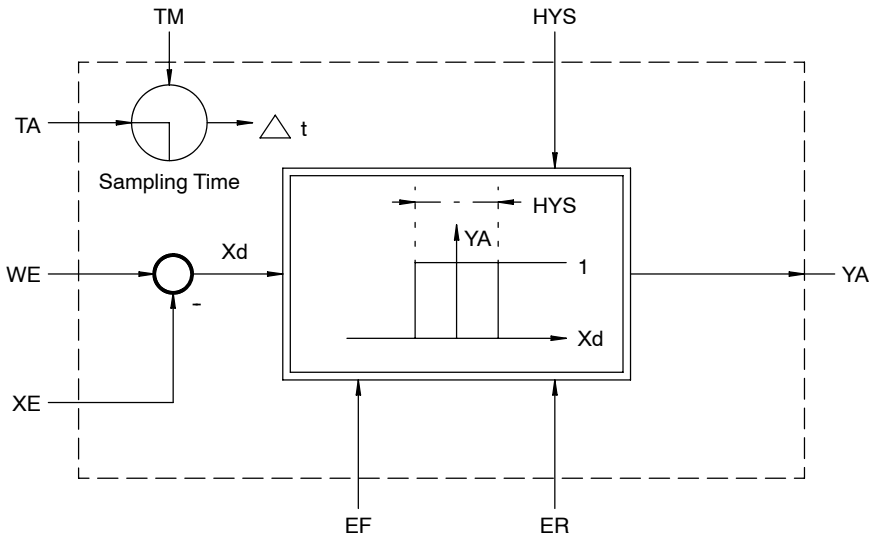


Figure 3 controller design

3 Configuration

The Function Block can be copied from source file (PADT or diskette) to the target file of selected PC station (ref. chapter LEERER MERKER).

3.1 Parameterization

The parameterization of ZR1 ensues with the assignment of the hysteresis and sampling times.

The hysteresis defines the operating points of the controller. Outside the hysteresis the system deviation causes ZR1 to switch the output depending on the sign of the deviation. Inside the hysteresis area ZR1 operates like a dead zone with stored output.

To select the sampling time is an option that can be done to synchronize ZR1 with other controllers. If synchronizing is not necessary the Function Blocks can be enabled to work in every program cycle by setting sampling time TA=0.

3.2 Reset of Function Block

ER = 1 reset of output marker YA.

EF = 0 no change in output marker condition even when the system deviation or controller parameters are changing.

3.3 FB operating times

☞ **Note** The given operating times are valid when using ALU 202.

Operating conditions :

ER = 1	0.52 ms
EF = 0	0.47 ms
ER = 0, EF = 1	1.5 ms

3.4 Program memory

first FB-call in OB:	1 596	Byte*
every further call:	+ 75	Byte

* The given value represents worst case value and is valid when the function block is the only one called in OB. If however commands used in your closed loop control functions already exist in your program, only the additional program parts will cause an increase in the total linked program length (hence saving in program memory).

FB311 PDSR1 PD-step-action controller for A120

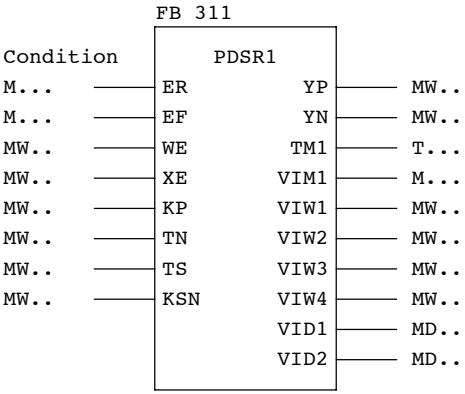
1 Function

The Function Block PDSR1 consists of a three-position controller hysteresis and a 1st order lag feedback loop. The internal coupling of 1st order lag element from controller output to the input summing point approaches controller characteristics of those in continuously sampling PD controllers (supposing relatively high system- and actuator time constants for efficient filtering of switched output signal). When connected with an integral actuator (e.g. control valve) the actuator/controller combination has PI characteristics. The parameterization is simplified by the direct assignment of the actuator-action time (nominal value of the valve) and the required parameters KP and TN. The determination of feedback- and hysteresis value is done by the controller itself.

- Parameterization of controller gain, integral action time, actuator action time and scaling value
- Internal determination of feedback- and hysteresis values
- Accommodation of the controller operation to the process conditions by the use of the scaling value KSN

2 Display

2.1 Function block symbol



2.2 FB structure

Assignable parameter		Meaning
PDSR1		Operation (Call)
ER	B - addr	function block reset; ER = 1: reset of YA
EF	B - addr	enable: EF = 0: freezes YP, YN
WE	MW - addr	setpoint value
XE	MW - addr	actual value
KP	MW - addr	controller gain
TN	MW - addr	integral-action time (in s)
TS	MW - addr	nominal actuating time of integral actuator (in s)
KSN	MW - addr	scaled process gain
YP	M - addr	controller output for positive directed actuating
YN	M - addr	controller output for negative directed actuating
TM1	T - addr	timer
VIM1	M - addr	internal organization data (bit)
VIW1	MW - addr	internal organization data (word)
VIW2	MW - addr	internal organization data (word)
VIW3	MW - addr	internal organization data (word)
VIW4	MW - addr	internal organization data (word)
VID1	MD - addr	internal organization data (double word)
VID2	MD - addr	internal organization data (double word)

2.3 FB structure

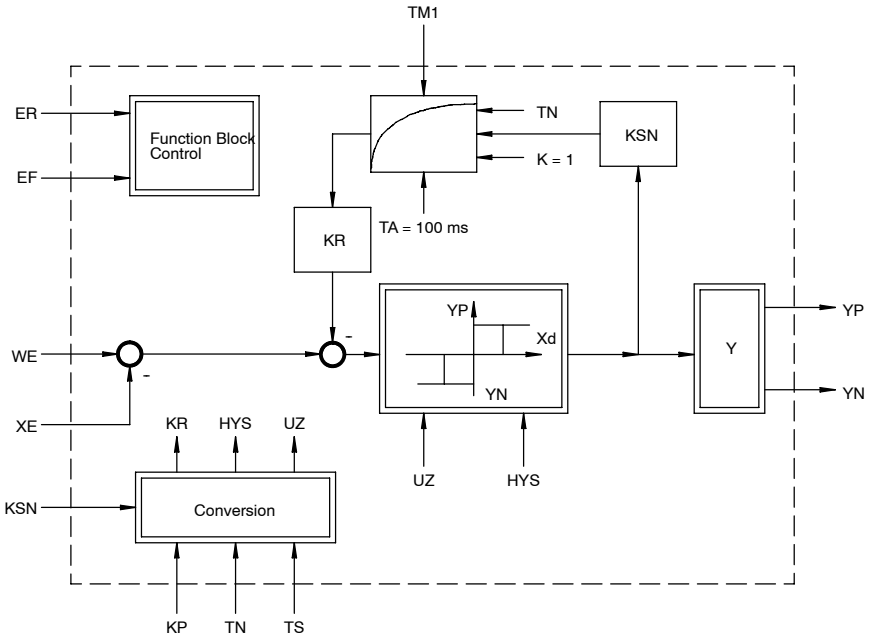


Figure 4 Controller design

3 Configuration

The Function Block can be copied from the source file (PADT or diskette) to the target file of the selected PC station (ref. chapter LEERER MERKER).

3.1 Parameterization

The parameterization of PDSR1 is carried out by the assignment of the controller gain, integral-action time, the nominal actuating time of integral actuator and the scaled process gain.

The gain of the 1st order lag feedback element is a function of scaled process gain KSN. Therefore KSN has to be determinated in relation to input scaling of controller setpoint- and actual value. For instance - a theoretical temperature range of +/-400 °C that refers to +/- 4000 integer value (e.g. scaling an input voltage signal of ADU204) results an input scaling of 10/ °C. If the maximum difference in process temperature (actual value between the states - shut down valve and widely opened valve-) results to KS = 200°C the scaled process gain is given to KSN = 2000.

The scaling accommodates the switching of the controller outputs to the appropriate switching of an integer value for feedback circuitry. In this way the transposition of the given parameters will be guaranteed and the handling of control loop can be done close to that of continuously operating loops.

To keep the developing controller attributes close to the determinated parameters the following values have to be selected:

Parameter	**min**	**type**	**max**
KP	1	-	-
TN	120	$\geq$ 4*TS	- (s)
TS	30	$\leq$ TN/4	- (s)

The hysteresis determines the controller sensitivity and is internally calculated the way:

HYS = KSN / (KP*TS)

When the scaling setpoint- and actual value to a function of twice the process gain (exampled above) the resolution error reaches at the most 1.66 %. If the user determination of integer range (not the scaling, hence KSN = constant) this is defined otherwise, the resolution changes while the absolute error remains the same.

3.2 Reset of Function Block

ER = 1 reset of output markers YP and YN.

EF = 0 no change in condition of output markers even when the system deviation or controller parameters are changing.

3.3 FB operating times

☞ **Note** The given operating times are valid when using ALU 202.

Operating conditions:

ER = 1	0.76	ms
EF = 0	0.67	ms
ER = 0, EF = 1	7.0	ms

3.4 Program memory

first FB-call in OB:	3 903	Byte*
every further call:	+ 117	Byte

* The given value represents worst case value and is valid when the function block is the only one called in OB. If however commands used in your closed loop control functions already exist in your program, only the additional program parts will cause an increase in the total linked program length (hence saving in program memory).

FB315 DR1 Three-position controller for A120

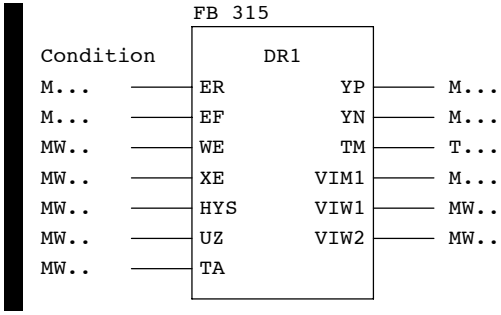
1 Function

The Function Block DR1 transforms an internally formed system deviation into binary states for output markers YP and YN. If the absolute value of the system deviation (WE-XE) overranges by half of the hysteresys value (HYS) which is shifted by dead band (UZ), the output will be set dependant (sign) on the deviation value (if positive - YP, if negative - YN). If system deviation falls below the value marked by the inner edge of appropriate hysteresis loop the marker will be reset. Overlapping of hysteresis loops can be done up to HYS = 2 * UZ

- Assigning hysteresis, dead band and sampling time
- Operation up to HYS = 2 * UZ possible
- Continuous operation setting TA = 0

2 Display

2.1 Function block symbol



2.2 FB structure

Assignable parameter		Meaning
DR1		Operation (Call)
ER	B - addr.	function block reset; ER = 1: reset of YA
EF	B - addr.	enable: EF = 0: freezes YA
WE	MW - addr.	setpoint value
XE	MW - addr.	actual value
HYS	MW - addr.	hysteresis
UZ	MW - addr.	dead band
TA	MW - addr.	sampling time (in 0.1 s); TA = 0 for continuous operation
YA	M - addr.	manipulated variable (controller output signal)
TM	T - addr.	timer
VIM1	M - addr.	internal organization data (bit)
VIW1	MW - addr.	internal organization data (word)
VIW2	MW - addr.	internal organization data (word)

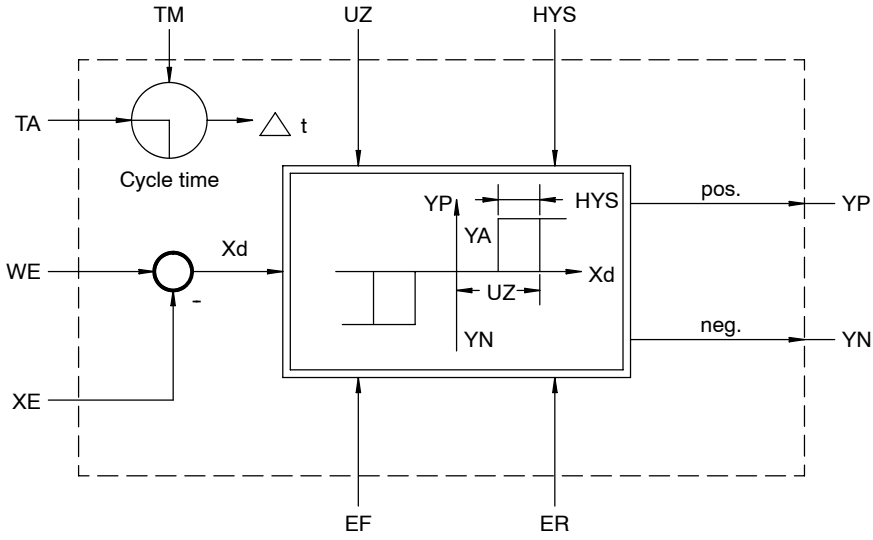


Figure 5 controller design

3 Configuration

The Function Block can be copied from the source file (PADT or diskette) to the target file of the selected PC station (ref. chapter LEERER MERKER).

3.1 Parameterization

The parameterization of Function Block ensues with assignement of hysteresis, dead band and sampling time. The hysteresis defines the operating points of the controller. Outside the hysteresis the system deviation causes DR1 to switch the appropriate output depending on the sign of the deviation. Inside the hysteresis area DR1 keeps the current output states as long as deviation does not over-range (underrange) the corresponding operating point (if high state - falling edge of hysteresis, if low state - rising edge of hysteresis). The separation of the deviation area for the use of two controller outputs allows the design of loop controls with separate control actions (split-range control, e.g. heating and cooling). The select sampling time TA is optional and can be used to synchronize DR1 with other controllers. If synchronization is not necessary the Function Blocks can be enabled to work in every program cycle by setting sampling time TA=0.

3.2 Reset of Function Block

ER = 1 reset of output markers YP and YN.

EF = 0 no change in condition of output markers even when the system deviation or controller parameters are changing.

3.3 FB operating times

☞ **Note** The given operating times are valid when using ALU 202.

Operating conditions :

ER = 1	0.6 ms
EF = 0	0.53 ms
ER = 0, EF = 1	1.2 ms

3.4 Program memory

first FB-call in OB:	1 623	Byte*
every further call:	+ 87	Byte

* The given value represents worst case value and is valid when the function block is the only one called in OB. If however commands used in your closed loop control functions already exist in your program, only the additional program parts will cause an increase in the total linked program length (hence saving in program memory).

FB320 PBM1 Pulse-duration Modulator for A120

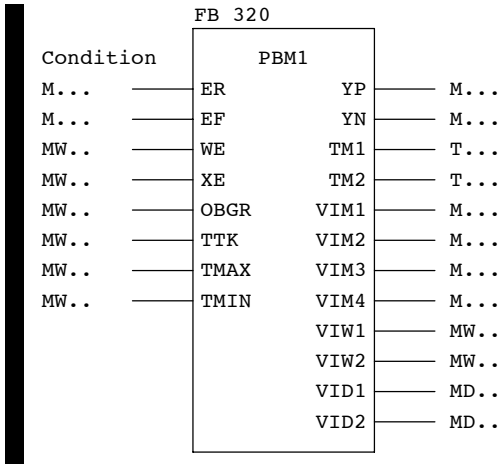
1 Function

Function Block PBM1 transforms an input signal, related to the given limiting value (OBGR), into a periodical pulse string with proportionally modulated pulse-width. The Function Block can be used as a P-controller (input WE, XE) and even as a transformer for continual signals (input WE with XE = 0) e.g. PID controller output connected to PBM1 for operating a two-point actuator of controllable system.

- Assign of sampling time, absolute input value causing permanent output signal and minimum/maximum pulse-width
- Transformation of negative values (YN)

2 Display

2.1 Function block symbol



2.2 FB structure

Assignable parameter		Meaning
PBM1		Operation (Call)
ER	B - addr.	function block reset; ER = 1: reset of YA
EF	B - addr.	enable: EF = 0: freezes YA
WE	MW - addr.	setpoint value
XE	MW - addr.	actual value
OBGR	MW - addr.	limiting value (absolute)
TTK	MW - addr.	sampling time (in s)
TMAX	MW - addr.	maximum pulse time (in s)
TMIN	MW - addr.	minimum pulse time (in s)
YP	M - addr.	output signal for positive directed actuation
YN	M - addr.	output signal for negative directed actuation
TM1	T - addr.	1st timer
TM2	T - addr.	2nd timer
VIM1	M - addr.	internal organization data (bit)
VIM2	M - addr.	internal organization data (bit)
VIM3	M - addr.	internal organization data (bit)
VIM4	M - addr.	internal organization data (bit)
VIW1	MW - addr.	internal organization data (word)
VIW2	MW - addr.	internal organization data (word)
VID1	MD - addr.	internal organization data (double word)
VID2	MD - addr.	internal organization data (double word)

3 Configuration

The Function Block can be copied from the source file (PADT or diskette) to the target file of selected PC station (ref. chapter LEERER MERKER).

3.1 Parameterization

The parameterization of PBM1 ensues with assignment of the limiting value, the sampling time and minimum/maximum pulse-width.

TTK determines the sampling time in which the actuating pulses are periodically given out to the controller outputs YP or YN. The actual pulse-width and thereby the averaged proportionality ym of the actuating pulses are dependant on the relation of the input value (system deviation or setpoint) to the limiting value (OBGR).

$$Tp = \frac{|WE - XE|}{OBGR} * TTK$$

$$ym = \frac{WE - XE}{OBGR} * 100\%$$

If the pulse-width underranges the given value TMIN the controller outputs are turned to low.

If pulse-width overranges the given value TMAX, the pulse-width will be limited to TMAX. Both measures ensure correct opeation between the modulator and the characteristics of a given actuator.

When assigning TMIN = 0 and TMAX = TTK the pulse-width is not restricted this way.

☞ **Note** To keep the developing controller attributes as close to the determinated parameters the following values should be selected:

Parameter	min	type	max
OBGR	10	-	-
TTK	-	-	3200 (s)
TMAX	-	≤ TTK	-
TMIN	0	< TMAX	-

3.2 Reset of Function Block

ER = 1 reset of output markers YP and YN.

EF = 0 no change in condition of output markers even when the system deviation or controller parameters are changing.

3.3 FB operating times

☞ **Note** The given operating times are valid when using ALU 202.

Operating conditions :

ER = 1	0.83 ms
EF = 0	0.73 ms
ER = 0, EF = 1	> 1.5 ms (3.45 ms maximum)

3.4 Program memory

first FB-call in OB:	3 309	Byte*
every further call:	+ 129	Byte

* The given value represents worst case value and is valid when the function block is the only one called in OB. If however commands used in your closed loop control functions already exist in your program, only the additional program parts will cause an increase in the total linked program length (hence saving in program memory).

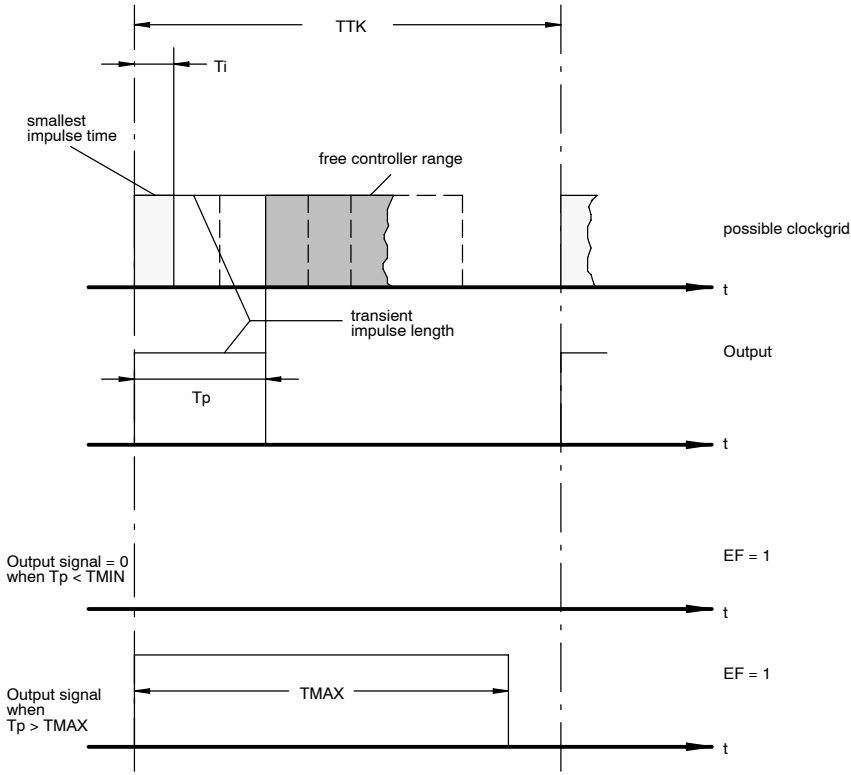


Figure 6 Clock grid and pulse-shaping

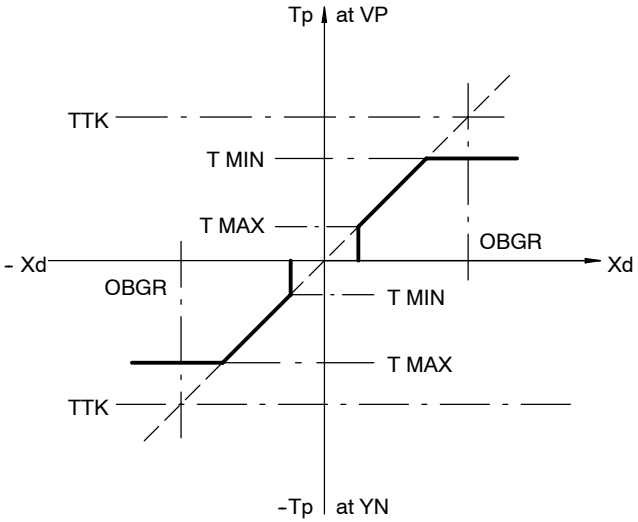


Figure 7 Transfer characteristics

Part III
Application

Chapter 1
Installation Application

This chapter tells you how to copy the applications of the AKF12 Closed Loop Control.

1.1 Installation of applications

The enclosed diskette contains two applications as example of close loop control using AKF12.

1.1.1 Installation of application HVAC

❒ Application of heating ventilation and air conditioning : ”HVAC”

Use the following procedure with the application:

Step1 Start AKF12 program

Step2 Insert CLC12-diskette in your disk drive (e.g. A:\)

Step3 You are in the Plant, entered during installation of AKF12 (e.g. ”C:\AKF12”)

Step4 Enter in the the AKF12 menu the station ”HVAC” under ”SeTup”, ”PC Station”, ”PC Station Name”

Step5 Select menu ”Special”, ”Copy Files”

Step6 To specify source files type: A:\CLC12*.* (note A:\ is the name of disk drive in which youve inserted the CLC12 diskette, eventually this drive can be B:\ )

Step7 When entering the return key in the ”Target” line (empty line), the files on the inserted diskette will be copied into the PC station determined with SeTup (CLC12)

Menu entries for step 6 and step 7:
(parameter: /V)

```
Start Copying Files
SOurce: A:\CLC12\*.*
Target:
Parameter: /V
```

Now you can take a look at the PC station ”HVAC”.

1.1.2 Installation of application REACT

❒ Application of a reacting tank in process engineering: ”REACT”

Use the following procedure with the application:

Step1 Start AKF12 program

Step2 Insert CLC12-diskette in your disk drive (e.g. A:\)

Step3 You are in the Plant, entered during installation of AKF12 (e.g. ”C:\AKF12”)

Step4 Enter in the the AKF12 menu the station ”REACT” under ”SeTup”, ”PC Station”, ”PC Station Name”

Step5 Select menu ”Special”, ”Copy Files”

Step6 To specify source files type: A:\CLC12*.* (note A:\ is the name of disk drive in which youve inserted the CLC12 diskette, eventually this drive can be B:\ )

Step7 When entering the return key in the ”Target” line (empty line), the files on the inserted diskette will be copied into the PC station determined with SeTup (CLC12)

Menu entries for step 6 and step 7:
(parameter: /V)

```
Start Copying Files
SOurce: A:\CLC12\*.*
Target:
Parameter: /V
```

Now you can take a look at the PC station ”REACT”. For a better understanding of the operation, in addition with the line comments available in IL mode, please notice the network comments of NW1 in OB and the comments in NW2 of the additional FBs.

Chapter 2
Applications

Instrumentation and control technology - Heating, Ventilation and Air Conditioning technology (HVAC)

The application originates from the production automation of chemical plants (batch process) including the additional building services automation. Open loop- and Closed Loop Control is respectively realized using Modicon A120 (ALU 202) central unit with I/O modules placed on basic rack and expansion subrack (ANSI). The networking to Modicon A350 central controller ensues with Modnet 1/SFB (1N procedure). In addition with visual display processor VIP101 and a directly connected operator panel the arrangement represents an example for central instrumentation and control technology (I&C) used for HVAC. The ”reacting-tank in process engineering” is achieved with the training board Modicon ET722. The board simulates level and temperature of a reacting tank by combined digital and analogue simulations.

The following application contains only the CLC-part ”HVAC” of the original PC station, because this part may be similar to some other applications in process engineering. The open loop part is too dependant on the handling characteristics of non CLC process appliances (like fans or flaps) or activities (like operating and monitoring of process). The open loop function therefore is only briefly described.

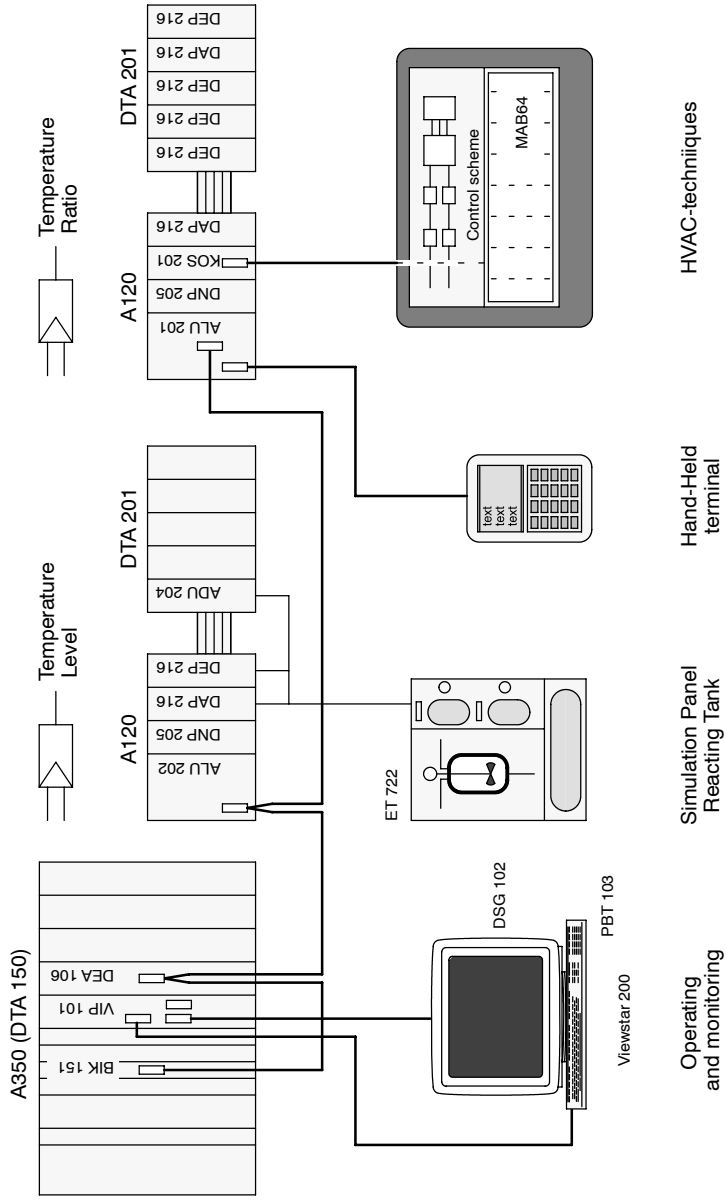


Figure 8 Application ”I&C techniques, HVAC techniques”

2.1 Open Loop and Temperature Control of a Ventilation System in HVAC Techniques

The process scheme is represented in Figure 9 and Figure 10. The CLC part described in chapter LEERER MERKER is located in PC station HVAC on the enclosed diskette (please read network comments and hints in NW1 of OB1).

For better understanding of the technology the essential open loop functions for operating the process will be described in the following.

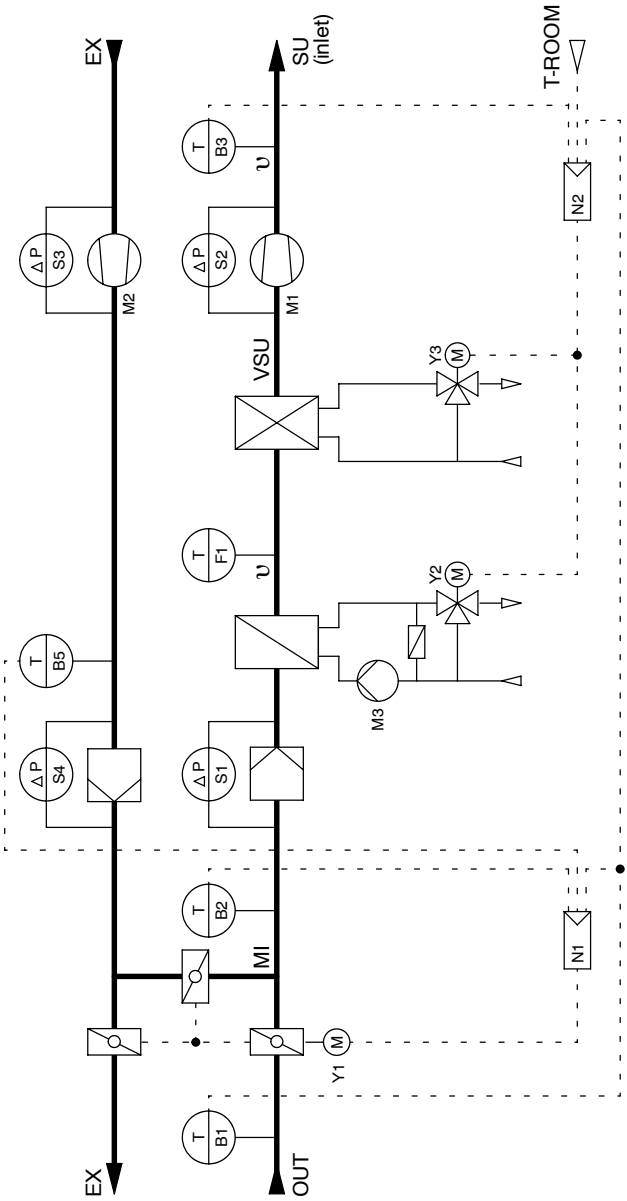


Figure 9 HVAC air conditioning

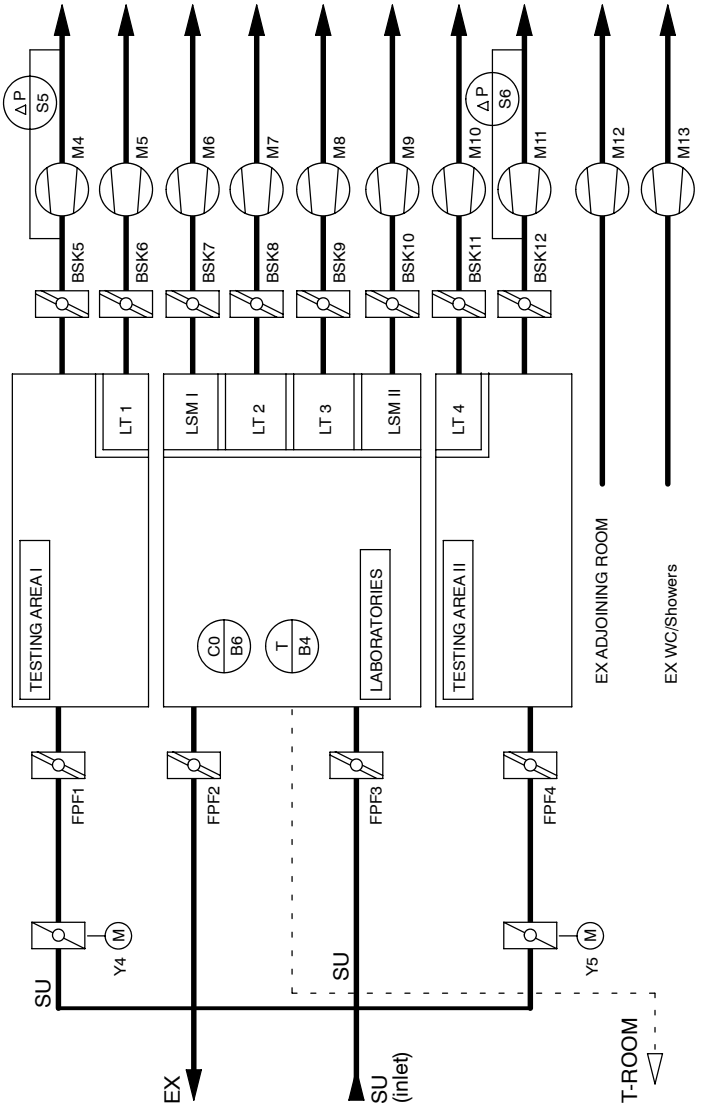


Figure 10 HVAC air distribution

2.1.1 Open Loop Control

In the automatic mode the system is turned on with 'I&C-remote' key, located on the operating and monitoring module MAB64. The following operating modes can be additionally activated from there and from VIP101

I&C	Day/On
Supply air fan M1	2nd speed
Exhaust air fan M2	2nd speed
Exhaust air fan M4	1st speed
Exhaust air fan M11	1st speed

	Night/Off low fan speed
Supply air fan M1	1st speed
Exhaust air fan M2	1st speed
Exhaust air fan M4	OFF
Exhaust air fan M11	OFF

Remote Control

If EXair fans M4 and M11 are in turned on state (2nd speed) the SUair fan M1 runs with 3rd speed. If EXair fans M4 or M11 and 2 from 4 laboratory tables are activated also the SUair fan M1 is running with 3rd speed. If 3 from 4 laboratory tables are in active state the SUair fan (M1) also runs with 3rd speed. With the FBs assigned for testing area I and II the corresponding EXair fans M4 and M11 will be changed to 2nd speed.

Exhaust Air Fans

The EXair fans (M6/M9) for the solvent boxes (LSM) are continuously operating.

The EXair fan for the adjoining rooms (M12) is turned on by the light switch and turned off with time delay after turning off the light.

The EXair fan for WC and showers is activated by the light switch (with time delay) when using WC or by humidity sensor (hygrostat) when using the shower cabins. When using only one room the fan runs with 1st speed. When using both rooms the EXair fan runs with 2nd speed.

Circulating Pump of Supply Air Heater

The circulating pump M3 is activated when the heater valve is opened and turned off when the heater valve is shut.

Frost Protection

If the outside temperature sinks below the protection value of 5 °C the fans (M1, M2, M4 and M11) are turned off. In this turned-off mode of the ventilation system the circulating pump is activated without respect to the key positions. The heater valve is opened and the cooler valve is shut.

Filter Maintenance Signal

The differential pressure switches S1 and S4 signalize polluted filters which have to be exchanged if the increasing differential pressure overranges given limits.

V-belt Control

The differential pressure switches S2, S3, S5 and S6 are controlling the differential pressure of the respecting fans. When a V-belt is broken the differential pressure vanishes, the respecting fan is turned off and the ventilation system signalizes a failure in process.

Fire Protecting Flap (FPF)

The Fire protecting flaps are shut by fusible links in the case of fire or fire hazard. The appropriate process units (SUair fans, EXair fans) are turned off.

Smoke Ventilation

The appliances for exhausting smoke are installed according to the regulations of the fire department. In this ventilation system the activating of ‘smoke ventilation’ mode sets SUair fan to run with 3rd speed and the EXair fans M2, M4 and M11 to run with 2nd speed. With manual control ‘Man/On’ at the switchgear cubicle the EXair fans can be turned on if required. The fire protecting flaps have to be opened before activating the smoke ventilation.

Signalling

The operating state of every system unit is displayed by the control module LED:

Ready - steady light
Failure - blinking light

If one single system unit has failed the system is turned off automatically (by PC program). The display lamps then turn off and the lamp corresponding to the failured unit starts blinking. After repair the ventilation system has to be turned into ‘automatic’ mode (acknowledge). All failure signals are collected in a special failure module. In this module the unit failures are signalling by blinking LEDs. The failure can be acknowledged with ”Ackn. failure” key. After proceeding in this way the blinking LEDs are turning to a steady light. This light is finally extinquished when the failed unit is repaired or exchanged by a new one.

Manual Control

Every drive (fan, circulating pump) can be activated separately in its different speeds by the corresponding keys of control module.

2.1.2 Mixed air temperature control

Application: Ventilation- and air conditioning systems in which...

- for save of heating energy the mixed air temperature is kept constant
- a minimum supply of outside air is to guarantee
- for save of cooling energy the supply of outside air is to minimize to a given limit.
- with change between summer- and winter mode the system has to be controlled by outside- and exhaust air temperature.

Function

The sensors B1, B2 and B3 measure the temperature of the outside air, mixed air and exhaust air. The P-controller (N1) compares the determinated setpoint value with the actual value of mixed air.

In cases of deviation, the actuating signal of P-controller output (N1) changes the flap positions in a way that system deviation can be compensated. The CLC-FB prevents the underrange of the determinated limiting value, for ensuring a minimum supply of outside air.

Closed Loop Control

Simultaneously with increasing outside air temperature the corresponding outside air flap opens. If the outside air temperature reaches the mixed air temperature setpoint, the outside air flap is opened wide and the mixed air flap is shut.

If the EXair temperature rises above the determined limit, the outside air flap is driven to minimum supply of outside air and the mixed air flap is opened.

In this case for the purpose of energy saving, it is more suitable to use mixed air enthalpy instead of mixed air temperature for control (not realized here).

With this pre-connected mixed air temperature control the influence on the process by disturbing changes in outside air temperature can be efficently compensated. That means the difference between the outside air temperature in summer

and the outside air temperature in winter is reduced to the smaller one between the mixed air temperatures. The following SUair system loop thereby is less burdened.

2.1.3 Room Temperature Control

Application

For systems with constant room temperature in winter time and a steadily increasing of room temperature in summer time (as a function of outside air temperature) e.g. bureaus, hotels, administration buildings, schools, theaters, laboratories etc.

Function

Sensor B1 measures the outside air temperature, sensor B3 measures SUair temperature and sensor B4 measures room temperature. The PPI-cascade control unit (N 2) includes the secondary control loop with PI-controller for SUair temperature control, this compensates for most of the disturbances to the system loop. The primary control loop with P-controller for room temperature control determines the setpoint value for the secondary control loop. With an increasing room temperature the setpoint for the SUair control decreases vice versa.

The cascade control unit N 2 compares the given setpoint value with the appropriate actual value. In cases of deviation the controller output (N 2) changes to compensation. The output signal of cascade control unit (N 2) operates sequentially with the actuators of the air heater and air cooler. For the purpose of energy saving and because of physiological reasons the room temperature should be increased relative to the rise of the outside air temperature (DIN 1946, part 2 - ref. Figure 11). To accomplish this demand the outside air temperature is applied to control unit N 2. To prevent the possibility of unhealthy draughts the system operation is determined in such a way that the SUair setpoint values are only valid within given limits. The limiting values therefore are set in the control unit.

Closed Loop Control Function

With the rise of room temperature the heater valve drives to direction ”Shut” and sequentially the cooler valve drives to direction ”Open”. If room temperature is too low, the cooler valve drives to direction ”Shut” and sequentially the heater valve to direction ”Open”.

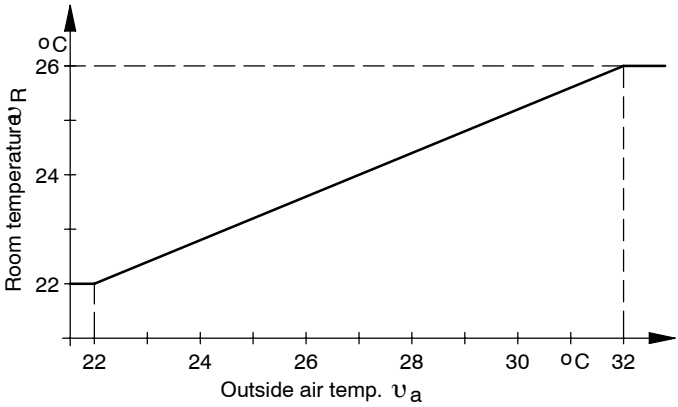


Figure 11 Setpoint value for room temperature vs. outside air temperature

The results of loop control operation are shown in Figure 12 and Figure 13. Figure 12 shows the reaction of the process where there is a step function change in outside air temperature. This disturbance change has no significance in practice but is done here to evaluate the control quality. Figure 13 shows the settling of the control loop after a system failure. In this test the system air loop itself was opened (EXair temperature = constant). The process settling after reactivation of circulating pump is similar to the settling caused by step change in outside air temperature. The disturbance, however is compensated more quickly because of the cancelled system meshing.

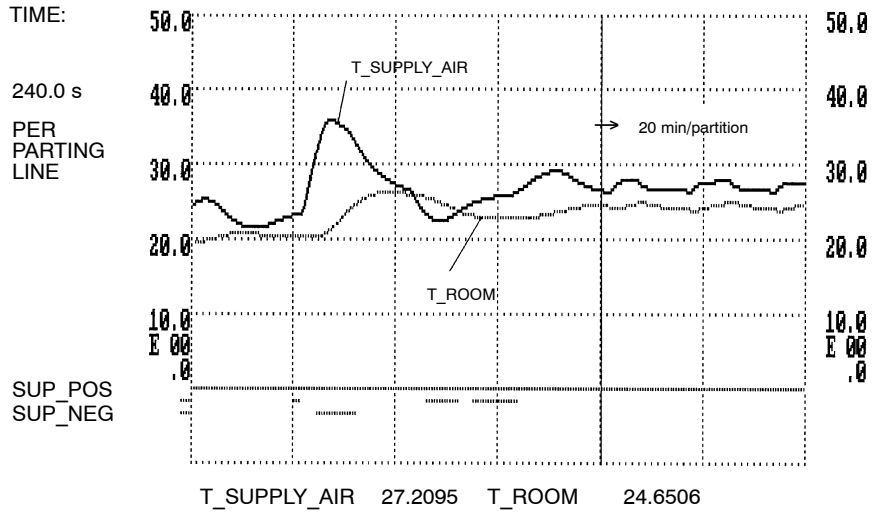


Figure 12 Loop control reaction after abrupt change in outside air temperature

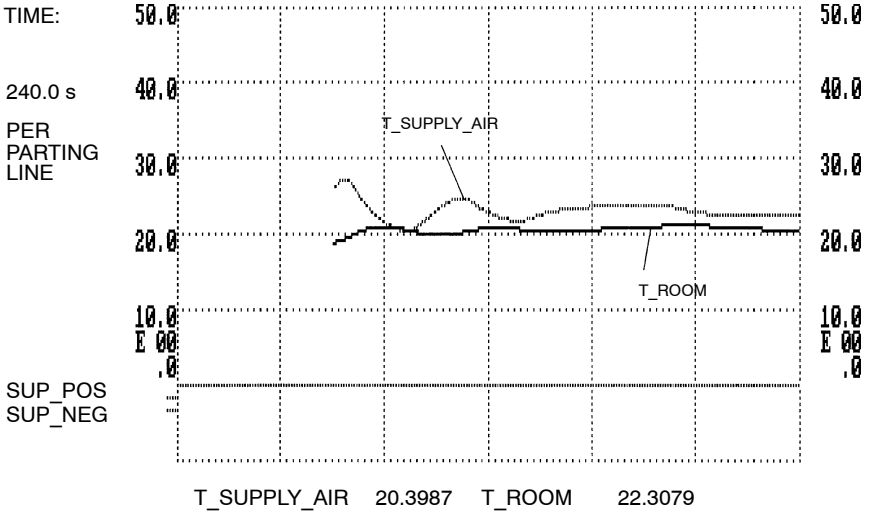


Figure 13 Settling of control loop after system failure (temporary failure of circulating pump)

2.2 Closed Loop Control of a Reacting Tank in Process Engineering

The process scheme is represented in Figure 14. The software described in chapter LEERER MERKER is located in PC station REACT on the enclosed diskette (please note network comments and hints in NW1 of OB1).

2.2.1 Sequence Control and Closed Loop Control

By controlled enabling of every function block, the AKF program realizes batch processing with fixed clock grid (ref. NW comment NW3, FB999 resp. NW2, FB1). The time sequences are:

- filling of tank to give setpoint value
- heating to given setpoint value
- cooling to fixed setpoint value
- clearing of tank

On the enabling the level controller the reacting tank starts filling to the given setpoint value. (The actual value is read as analogue value from the input module.) The assigned two-position controllers operate as limit monitors. Disturbances caused by opening of 2nd inlet valve leads to an earlier attainment of the setpoint and to an earlier turn-off of the controller operated valve V2. Overfilling is not compensated for additional emptying of the tank, because the tank contents should not be taken out before the heating and cooling periods are complete. If the setpoint level can not be reached in the given sequence time, the following batch is carried out with a small quantity of product tank level.

After locking the level controller, the three-position temperature controller is activated with its first temperature setpoint value. (The actual value is read as an analog value from input module.) The temperature control is performed as a split-range control for both of the setpoint values. The control inlet valve AV2 of the heating system (here operated binary) is opened together with drain valve V5 for heating. For cooling the tank the valves V3 and V4 are opened. Hysteresis and dead band of controller are selecting way that there is no need for cool-

ing pulses during the heating period and no need for heating pulses during the cooling period. If setpoint temperature can not be reached in a given sequence time, the following batch is carried out with a reduced temperature of the tank contents.

By changing over to the second, internally determined temperature setpoint (in FB1), the cooling period begins. If the setpoint temperature cannot be reached in the given sequence time, the chemical product is discharged with its temperature reached up to that time.

The time for discharging the tank is calculated in such a way that the complete clearing is guaranteed.

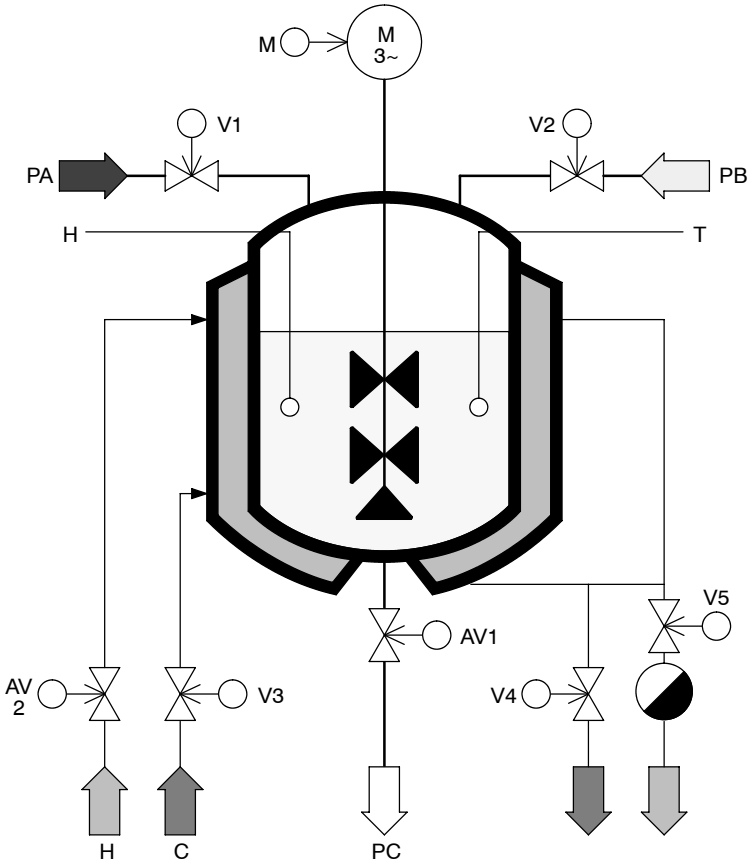


Figure 14 Reacting tank in process engineering

Part IV
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